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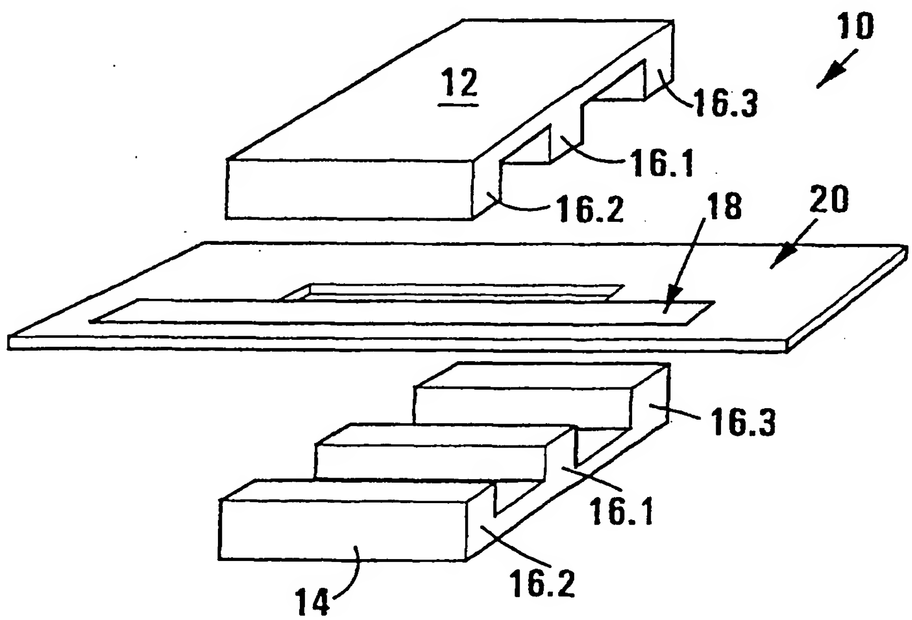
(54) Title: PLANAR TRANSFORMER

(57) Abstract

A planar transformer is provided which includes an E-shaped core with a central leg and spaced adjacent legs, a primary winding, and first and second secondary tracks. The primary winding is defined on a primary layer through which the central leg of the core extends. The first secondary track is defined on a first secondary layer, the first secondary track comprising a plurality of serially interconnected segments each defining a secondary winding which comprises a partial turn configured to provide a predefined low output voltage of the transformer. The second secondary track is defined on a second secondary layer, the second secondary track being arranged in mirror image fashion relative to the first secondary track. The secondary track may define an end region operatively subject to leakage inductance from an adjacent leg of the core to reduce the voltage in a secondary leg in an inductive manner.



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PLANAR TRANSFORMER

THIS INVENTION relates to a planar transformer. It also relates to a method of balancing cores of a planar transformer, and to a power supply for electrical apparatus including the planar transformer.

Conventional planar transformers typically include a ferrite core which has spaced legs which extend through a plurality of layers on which a primary and a plurality of secondary windings are provided thereby to supply different output voltages. Typically, in order to provide different output voltages at sufficient currents, the secondary windings are provided on different layers thereby increasing the physical size of the transformer. It is an object of this invention to offer a solution to this problem.

According to the invention there is provided a planar transformer which includes

a core;

a primary winding defined on a primary layer through which the core extends;

a first secondary track defined on a first secondary layer, the first secondary track comprising a plurality of serially interconnected segments each defining a secondary winding; and

a second secondary track defined on a second secondary layer, the second secondary track being arranged in mirror image fashion relative to the first secondary track.

Typically, the coupling of each of the first and second tracks with the flux over each half-cycle is unbalanced. However, due to the arrangement of the tracks in a mirror image fashion, the coupling with the flux over a full cycle is balanced. Likewise, in certain embodiments, coupling of at least some of the segments of the first and second tracks with the flux over each half-cycle may be unbalanced but balanced over a full-cycle. Further, it is to be appreciated that the first secondary track, which is arranged in a mirror fashion relative to the second secondary track, may form part of a larger track including further contacts or the like.

Further in accordance with the invention, there is provided a planar transformer which includes

an E-shaped core with a central leg and spaced adjacent legs;

a primary winding defined on a primary layer through which the central leg of the core extends;

a first secondary track defined on a first secondary layer, the first secondary track comprising a plurality of serially interconnected segments each defining a secondary winding which comprises a partial turn configured to provide a predefined low output voltage of the transformer;

a second secondary track defined on a second secondary layer, the second secondary track being arranged in mirror image fashion relative to the first secondary track; and

a plurality of contacts from which at least one multiple of the predefined low output voltage is tapped.

The first and second secondary layers may be integrally formed e.g., they may be tracks provided on opposed sides of a double

sided printed circuit board. Instead, the first and the second secondary layers may be defined by two separate printed circuit boards. It is to be appreciated that the tracks may be defined on the layers with any other technology e.g. thin or thick film technology or the like.

The transformer may include a plurality of first and secondary tracks. Typically, associated first and second secondary tracks are provided on opposed sides of a printed circuit board. The transformer may this include a plurality of printed circuit boards through which the core extends. The plurality of first secondary tracks and the plurality of second secondary tracks may be connected in series. In certain embodiments of the invention, the transformer is arranged to be upgraded. Thus, further printed circuit boards may be added to enhance the power handling capabilities of the transformer.

The core is typically a ferrite core having an E-shape and the primary winding and secondary tracks typically extend about a central leg of the E-shaped core. The transformer may include a plurality of primary windings in a series and/or parallel configuration which provide one or more sources of flux for coupling with the secondary windings.

In order to enhance the current carrying capabilities of the segments, the transformer may include surface mount plates, e.g. copper plates, mounted to the segments. Cooling fins may be provided to enhance heat dissipation.

Still further in accordance with the invention, there is provided a planar transformer which includes

a core including a central leg and at least one spaced adjacent leg; and

a secondary track formed by a plurality of segments which define a secondary winding, the secondary track defining an end region operatively subject to leakage inductance from the adjacent leg thereby to reduce the voltage in the secondary leg in a reactive manner.

The transformer may include a primary winding defined on a primary layer through which the core extends, the secondary track including

a first secondary track defined on a first secondary layer, the first secondary track comprising a plurality of serially interconnected segments each defining a secondary winding; and

a second secondary track defined on a second secondary layer, the second secondary track being arranged in a mirror image fashion relative to the first secondary track.

Further in accordance with the invention, there is provided a method of reactively reducing the voltage in a secondary track of a planar transformer, the method including arranging an end region of the secondary track so that it is operatively subject to leakage inductance from the core.

Each segment of the secondary track may be at least a partial turn about the core, typically a partial turn about the central leg of the core thereby to enable preselected voltages to be tapped from the secondary tracks. Accordingly, when the core is an E-shaped core, there may be a different number of segments on a particular secondary layer between adjacent legs of the core and a central leg of the core resulting

in an unbalanced transformer at that particular level. However, due to the mirror image arrangement of the first and secondary tracks, the transformer is balanced over a full cycle as the cumulative number of tracks between each adjacent leg and the central leg is balanced.

Accordingly, further in accordance with the invention, there is provided a method of balancing a core of a planar transformer, the method including

providing a planar transformer which includes first and second secondary tracks, the first and second secondary track each including a plurality of serially interconnected segments defining first and second secondary windings each of which includes at least one partial turn about a core of the transformer; and

arranging the first and secondary tracks in such a fashion so that they lie in a mirror image fashion relative to each other thereby to balance the core of the transformer.

The method may include synchronous switching by means of conventional switching circuitry between corresponding segments provided on the first and second tracks. Accordingly, corresponding segments may each define a secondary sub-winding which cumulatively provide preselected output voltages.

Still further in accordance with the invention there is provided a power supply for electrical apparatus, the power supply including

a planar transformer as hereinbefore described; and

switching circuitry connected to selected segments of the transformer for selectively providing an output voltage from corresponding segments.

The first and second tracks are typically spiraform and are preferably in the form of copper tracks of a printed circuit board. Each segment of the track is typically rectangular in outline. As mentioned above, the segments are serially interconnected to define first and second secondary windings and the segments preferably increase in width from a centre of the spiraform to a periphery of the spiraform.

The transformer may include a plurality of contacts provided at opposed ends of selected segments. Accordingly, the method may include synchronously tapping a plurality of different voltages from corresponding segments of the first and secondary tracks by means of switching circuitry.

In order to enhance the current carrying capability of each segment associated with a particular output voltage, the width of each segment should be increased which, in turn, limits the number of segments which may be provided between a central leg and an adjacent leg of a particular core.

The invention is now described, by way of example, with reference to the accompanying diagrammatic drawings.

In the drawings,

Figure 1 shows an exploded three-dimensional view of part of a planar transformer in accordance with the invention;

Figure 2 shows a schematic representation of a lateral section of a further embodiment of part of a planar transformer in accordance with the invention;

Figure 3 shows an equivalent circuit of the transformer of Figure 2;

Figure 4 shows a top plan view of the further embodiment of a planar transformer in accordance with the invention;

Figure 5 shows a sectional bottom plan view of the transformer of Figure 4;

Figure 6 shows the equivalent circuit of the planar transformer of Figures 4 and 5;

Figure 7 shows a sectional top plan view of a yet further embodiment of a planar transformer in accordance with the invention;

Figure 8 shows a sectional bottom plan view of the transformer of Figure 7;

Figure 9 shows an electrical equivalent of the transformer of Figures 7 and 8;

Figure 10 shows a sectional top plan view of a planar transformer, also in accordance with the invention, including leakage inductance;

Figure 11 shows a sectional bottom plan view of the transformer of Figure 10;

Figure 12 shows a sectional top plan view of a further embodiment of a planar transformer, in accordance with the invention, including leakage inductance; and

Figure 13 shows a sectional bottom plan view of the transformer of Figure 12.

Referring to the drawings, reference numeral 10 generally indicates a part of a planar transformer in accordance with the invention.

The transformer 10 includes top and bottom ferrite core components 12, 14, respectively, which define a transformer core including a central leg 16.1 and spaced adjacent legs 16.2 and 16.3. The transformer 10 includes a primary layer on which is provided a primary winding (not shown) through which the central leg 16.1 of the core extends, a first secondary track 18 etched onto an upper surface of a printed circuit (PC) board 20, and a second secondary track (not shown) which is etched onto a bottom surface of the PC board 20 in a mirror image fashion. The track 18 defines a segment which extends between the legs 16.1 and 16.2 to define a secondary winding which is in the form of a half-turn. The voltage across the segment is a highest common denominator of further voltages provided by further secondary windings provided on the transformer 10 as described in more detail below. The transformer 10 is connected to switching circuitry (not shown) which selectively switches between the track 18 and its mirror image provided on the lower surface of the PC board 20 to provide a plurality of output voltages for electronic apparatus such as a personal computer or the like.

Referring in particular to Figures 2 and 3 of the drawings, reference numeral 30 generally indicates a further embodiment of a planar transformer in accordance with the invention. The transformer 30 includes first and second cores 32, 34, respectively, each of which includes a central leg 32.1, 34.1 and two spaced adjacent legs 32.2, 34.2 and 32.3, 34.3 respectfully. As in the case of the transformer 10, the transformer 30 includes a secondary track having segments 36.1 to 36.3 which each make a single pass between the central legs 32.1, 34.1 and adjacent legs 32.2, 32.3, and 34.3. Contacts 38, 40, 42, 44, 46 and 48 are provided selectively to tap various voltage from the segments 36.1 to 36.3. The track is etched onto a PC board (not shown) in a

conventional fashion and opposed surfaces of the PC board include similar tracks which are mirror images of each other. Further, as is the case with the transformer 10, each segment 36.1 defines the largest common denominator of the output voltage required from the transformer 30 and are serially interconnected (see Figure 3).

Referring in particular to Figures 4 to 6 of the drawings, reference numeral 50 generally indicates a further embodiment of a planar transformer in accordance with the invention. As is the case with the planar transformers 10 and 30, the planar transformer 50 includes a primary winding defined on a primary layer (not shown) through which a central leg 52.1 of a core extends. The core includes spaced adjacent legs 52.2 and 52.3. The transformer 50 includes a first secondary track 54 which is a copper track etched on a first side 55 of a PC board 56 which defines a first secondary layer. An opposed second side 60 of the PC board 56 includes a second secondary track 58 which is also in the form of a copper track etched onto the PC board 56.

The first secondary track 54 includes a plurality of copper segments 62.1, 64.1, 66.1, 68.1, 70.1, 72.1, and 74.1 which are serially interconnected. The second secondary track 58 includes corresponding copper segments 62.2, 64.2, 66.2, 68.2, 70.2, 72.2, and 74.2 which are mirror images of the first secondary track 54. Each segment 62.1 to 74.1 and 62.2 to 74.2 is defined by a portion of the track which extends between the central leg 52.1 and adjacent legs 52.2 and 52.3. As seen in Figure 4, four segments, namely segments 62.1, 66.1, 70.1, and 74.1, of the first secondary track 54 pass between the adjacent leg 52.2 and the central leg 52.1, as opposed to three segments, namely segments 64.1, 68.1 and 72.1, which pass between

the central leg 52.1 and the adjacent leg 52.3. Accordingly, the segments 62.1 to 74.1 provided on the first secondary track 54 result in an unbalanced transformer. However, due to the mirror image of the second secondary track 58 provided on an opposed side of the PC board 56, four segments, namely segments 62.2, 66.2, 70.2 and 74.2, pass between the central leg 52.1 and the adjacent leg 52.3. The first and second secondary tracks 54 and 58 are connected to switching circuitry (see Figure 6) which selectively taps voltages from the various segments 62.1 to 74.1 and 62.2 to 74.2 resulting in a balanced transformer over a complete cycle.

The segment 62.1 has a contact 76.1 which is connected to a contact 76.2 of the segment 62.2 and the contacts are grounded (see Figure 6). The segment 62.1 is connected via a connecting copper track 80.1 to the segment 64.1 which, in turn, has a contact 82.1 connected to contacts 84 of the switching circuitry. The contact 82.1 is connected via a copper connecting track 86.1 to the segment 66.1 which is connected via a contact 88.1 to further contacts 90 (see Figure 6) of the switching circuitry. The contact 88.1 is connected via a connecting copper track 92.1 to the segment 68.1 which is serially connected via a connecting copper track 94.1 to the segment 70.1 which, in turn, is connected via a copper track 96.1 to the segment 72.1 and, finally, via a copper track 98.1 to the segment 74.1 which has its contact 100.1 connected to contacts 102 of the switching circuitry. The segments 62.1 to 74.1 thus define seven secondary sub-windings which are each in the form of a half-turn and interconnected in series. In a similar fashion, the segments 62.2 to 74.2 are serially interconnected in a mirror image fashion. Power is tapped from selected

contacts 82.1, 82.2, 88.1, 88.2, 100.1 and 100.2 via the switching circuitry.

Referring in particular to Figures 7 to 9 of the drawings, reference numeral 110 generally indicates a further embodiment of a planar transformer in accordance with the invention. The planar transformer 110 resembles the transformer 30 (see Figures 2 and 3) and, accordingly, like reference numerals have been used to indicate the same or similar features unless otherwise indicated.

The transformer 110 includes first and second ferrite cores 32, 34, each having a central leg 32.1, 34.1 and spaced adjacent legs 32.2, 32.3, and 34.2 and 34.3, respectively. The transformer 110 includes primary windings in the form of copper tracks etched onto a PC board (not shown) which are spiraform and which encircle the central legs 32.1 and 34.1 to generate multiple sources of flux. The transformer 110 further includes a first secondary track 54 in the form of a copper track which has been etched onto a first layer of a PC board (not shown) and a secondary track 58 which is etched onto an opposed or second secondary layer of the PC board. As is the case with the transformers 10, 30, 50, the transformer 110 has its first and second secondary tracks 54, 58 laid out in a mirror image fashion, thereby to balance the transformer 110. Further, as in the case with the transformers 10, 30, 50, the first secondary track 54 of the transformer 110 includes seven voltage segments 62.1, 64.1, 66.1, 68.1, 70.1, 72.1, and 74.1. Likewise, the second secondary track 58 includes seven voltage segments 62.2, 64.2, 66.2, 68.2, 70.2, 72.2, and 74.2, which are laid out on an opposed side of the PC board in a mirror image fashion. Unlike the transformer 50 (see Figures 4 to 6) which includes a single core, the

transformer 110 includes the two cores 32, 34 and, accordingly, the number of passes or the number of segments 62 to 74 between each central leg 32.1, 34.1 and adjacent side legs 32.2, 32.3, 34.2, and 34.3, may be reduced. Accordingly, for a core of standard dimensions, the thickness of the segments 62.1 to 74.1 and 62.2 to 74.2 may be greater, thereby permitting a greater current carrying capability of the transformer 110 as opposed to the transformer 50.

Referring in particular to Figures 10 to 13 of the drawings, reference numerals 120 and 130 generally indicate further embodiments of a planar transformer in accordance with the invention. The planar transformers 130, 120 resemble the planar transformer 50 (see Figures 4 to 6) and the planar transformer 110 (see Figures 7 to 8), respectively, and accordingly like reference numerals have been used to indicate the same or similar features unless otherwise indicated.

In the transformer 110, the segments 62.1 and 74.1 of the first secondary track 54 pass between the central legs 32.1 and 34.1 and adjacent spaced side legs 32.2 and 34.2. The mirror image segments 62.2 to 74.2 pass between the central legs 32.1 and 34.1 and the adjacent legs 32.3 and 34.3. However, in the transformer 120, the segments 72.1 and 74.1 of the first secondary track 54 do not pass between the central legs 32.1, 34.1 and adjacent legs 32.2, 34.2, but are cranked outwardly and pass outwardly of the adjacent legs 32.3 and 34.3 to subject the segments 72.1 and 74.1 to leakage inductance. Likewise, segments 72.2 and 74.2 of the second secondary track 58 pass outwardly of the adjacent legs 32.2 and 34.2. The leakage inductance experienced by the segments 72.1, 74.1, 72.2, 74.2 of the transformer 120 in conjunction with the interwinding and inter-turn

capacitance are preferably used for soft switching topologies. Typically, the layout is used when primary windings are placed on more than one layer of the transformer 120 and inter-turn capacitance originates between each track turn and the interwinding capacitance originates between layers of windings. In this regard, it is important to appreciate that although the embodiments of the invention depicted above include a single double-sided PC board which has been etched on both sides in a mirror image fashion, the transformers 10, 30, 50, 110, 120, and 130 may be in the form of multi-layered transformers including a plurality of PC boards with secondary and primary tracks etched thereon.

Referring in particular to Figures 12 and 13 of the drawings, the transformer 130 includes further segments 132.1 and 132.2 on its first and second secondary tracks 54, 58, respectively, which are located outwardly of the adjacent secondary legs 52.2 and 52.3. As in the case of the transformer 120, the further segments 132.1 and 132.2 experience leakage inductance which may be used to tune the output voltage from the transformer.

When designing the transformers 10, 30, 50, 110, 120, and 130 the minimum voltage required from the transformer is determined and the transformer is configured so that the voltage across a single segment is equal to the largest common denominator of the voltages required. For example, for a power supply for a personal computer requiring 1.7 V, 3.3 V, 5 V and 12 V, the transformer 10, 30, 50, 110, 120, and 130 is configured so that the voltage across each segment is 1.7 V (regulated to 1.7 V by means of the switching circuitry). For example, 1.7 V may be tapped off in a half-cycle fashion from segments 66.1, 66.2 between contacts 82.1 and 88.1, and 82.2

and 88.2, respectively in the transformer 50 (see Figures 4 to 6). A 3.4 V output may be obtained from the segments 62.1 and 64.1, 62.2 and 64.2 by tapping off between contacts 76.1 and 82.1, and 76.2 and 82.2. The voltage may then be regulated by the switching circuitry and its regulation means to 3.3 V. A 5.1 V output may be obtained by tapping off between contacts 76.1 and 88.1, and 76.2 and 88.2 and thereafter regulated to 5 V. Likewise, a 12 V output may be obtained from the contacts 76.1 and 100.1, 76.2 and 100.2. As the current drawn from the inner segments 62 and 64 is greater than, for example, the current drawn from the outer segment 74, the thickness or width of the segments increase towards the central leg 52.1 of the transformer 50.

The Inventors believe that the invention, as illustrated, provides an enhanced planar transformer 50, 110, 120, and 130 which is particularly suited for use in computer equipment. As the number of passes of each track, i.e. the number of segments, between the central leg 52.1 and adjacent legs 52.2 and 52.3 of the transformer 50, and the central leg 32.1, 34.1 and the adjacent legs 32.2 and 34.2 of the transformer 110 are minimised, the thickness of the tracks may be increased, thereby to provide a greater current carrying capability. Further, as the copper tracks which define the segments 62.1 to 74.1 and 62.2 to 74.2 are a mirror image of each other, the transformer is balanced over a complete cycle, thereby reducing saturation problems within the core of the transformer.

CLAIMS

1. A planar transformer which includes

a core;

a primary winding defined on a primary layer through which the core extends;

a first secondary track defined on a first secondary layer, the first secondary track comprising a plurality of serially interconnected segments each defining a secondary winding; and

a second secondary track defined on a second secondary layer, the second secondary track being arranged in mirror image fashion relative to the first secondary track.

2. A planar transformer which includes

an E-shaped core with a central leg and spaced adjacent legs;

a primary winding defined on a primary layer through which the central leg of the core extends;

a first secondary track defined on a first secondary layer, the first secondary track comprising a plurality of serially interconnected segments each defining a secondary winding which comprises a partial turn configured to provide a predefined low output voltage of the transformer;

a second secondary track defined on a second secondary layer, the second secondary track being arranged in mirror image fashion relative to the first secondary track; and

a plurality of contacts from which at least one multiple of the predefined low output voltage is tapped.

3. A planar transformer which includes

a core including a central leg and at least one spaced adjacent leg; and

a secondary track formed by a plurality of segments which define a secondary winding, the secondary track defining an end region operatively subject to leakage inductance from the adjacent leg thereby to reduce the voltage in the secondary leg in a reactive manner.

4. A transformer as claimed in Claim 3, which includes a primary winding defined on a primary layer through which the core extends, the secondary track including

a first secondary track defined on a first secondary layer, the first secondary track comprising a plurality of serially interconnected segments each defining a secondary winding; and

a second secondary track defined on a second secondary layer, the second secondary track being arranged in a mirror image fashion relative to the first secondary track.

5. A transformer as claimed in any one of the preceding claims 1 or 2 or 4, in which the first and second secondary tracks are arranged so that the coupling of each of the first and second secondary tracks with flux over each half-cycle is unbalanced and the coupling with the flux over a full cycle is balanced.

6. A transformer as claimed in Claim 5, in which the tracks are arranged so that coupling of at least some of the segments of the first and second secondary tracks with the flux over each half-cycle is unbalanced but balanced over a full-cycle.

7. A transformer as claimed in any one of the preceding claims 4 to 6 inclusive, in which each segment is at least a partial turn about the core, thereby to enable preselected voltages to be tapped from the secondary tracks.

8. A transformer as claimed in any one of the preceding claims 4 to 7 inclusive, in which the first and second secondary layers are integrally formed so that the tracks are provided on opposed sides of a double sided printed circuit board.

9. A transformer as claimed in any one of the preceding claims 4 to 7 inclusive, in which the first and the second secondary layers are defined by two separate printed circuit boards.

10. A transformer as claimed in any one of the preceding claims 4 to 9 inclusive, which includes a plurality of first and second secondary tracks.

11. A transformer as claimed in Claim 10, in which at least two of the first secondary tracks and at least two of the second secondary tracks are connected in parallel.

12. A transformer as claimed in any one of the preceding claims 4 to 11 inclusive, in which the core is a ferrite core having an E-shape and the primary winding and secondary tracks typically extend about a central leg of the E-shaped core.

13. A transformer as claimed in Claim 12, in which there are a different number of segments on a particular secondary layer between

adjacent legs of the core and a central leg of the core resulting in an unbalanced transformer at that particular level, however, due to the mirror image arrangement of the first and secondary tracks, the transformer is balanced over a full cycle as the cumulative number of tracks between each adjacent leg and the central leg is balanced.

14. A transformer as claimed in any one of the preceding claims 4 to 13 inclusive, which includes a plurality of primary windings which provide at least one source of flux for coupling with the secondary windings.

15. A transformer as claimed in any one of the preceding claims 4 to 14 inclusive, which includes surface mount plates mounted to the segments in order to enhance the current carrying capabilities of the segments.

16. A transformer as claimed in any one of the preceding claims 4 to 15 inclusive, which includes cooling fins to enhance heat dissipation.

17. A transformer as claimed in any one of the preceding claims 4 to 16 inclusive, in which the first secondary track forms part of a larger track including further electrical contacts.

18. A transformer as claimed in any one of the preceding claims 4 to 16 inclusive, in which the first and second secondary tracks are spiraform and are in the form of copper tracks of a printed circuit board.

19. A transformer as claimed in Claim 18, in which the segments are serially interconnected to define the first and second secondary windings and the segments increase in width from a centre of the spiraform to a periphery of the spiraform.

20. A transformer as claimed in any one of the preceding claims, which includes a contact provided at each opposed end of selected segments.

21. A transformer as claimed in any one of the preceding claims, in which the transformer is arranged to be upgraded, the core being dimensioned to allow further printed circuit boards to added to enhance the power handling capabilities of the transformer.

22. A method of reactively reducing the voltage in a secondary track of a planar transformer, the method including arranging an end region of the secondary track so that it is operatively subject to leakage inductance from the core.

23. A method of balancing a core of a planar transformer, the method including

providing a planar transformer which includes first and second secondary tracks, the first and second secondary tracks each including a plurality of serially interconnected segments defining first and second secondary windings each of which includes at least one partial turn about a core of the transformer; and

arranging the first and secondary tracks in such a fashion so that they lie in a mirror image fashion relative to each other thereby to balance the core of the transformer.

24. A method as claimed in Claim 23, which includes synchronously switching between corresponding segments provided on the first and second secondary tracks, thereby cumulatively to provide preselected output voltages sourced from corresponding segments each defining a secondary sub-winding.

25. A method as claimed in Claim 24, which includes synchronously tapping a plurality of different voltages from corresponding segments of the first and secondary tracks by means of switching circuitry.

26. A power supply for electrical apparatus, the power supply including

a planar transformer as claimed in any one of the preceding claims 1 to 21 inclusive; and

switching circuitry connected to selected segments of the transformer for selectively providing an output voltage from corresponding segments.

27. A new planar transformer, substantially as herein described and illustrated.

28. A new method of reactively reducing the voltage in a secondary track of a planar transformer, substantially as herein described and illustrated.

29. A new method of balancing the core of a planar transformer, substantially as herein described and illustrated.

30. A new power supply, substantially as herein described and illustrated.

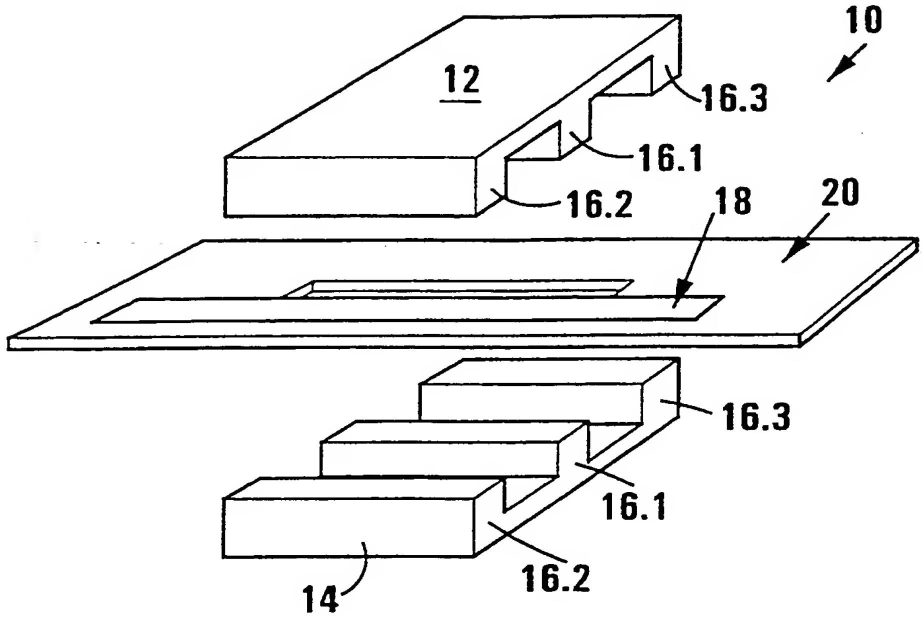


FIG 1

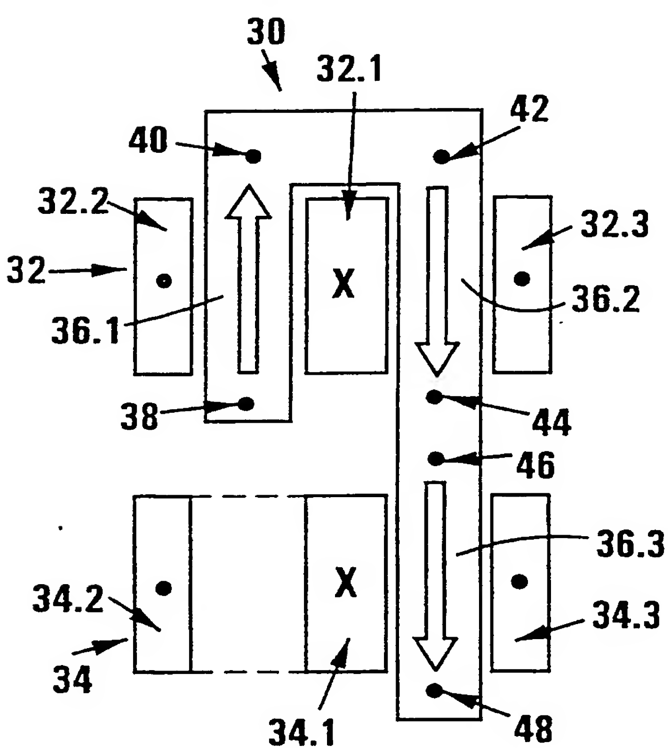


FIG 2

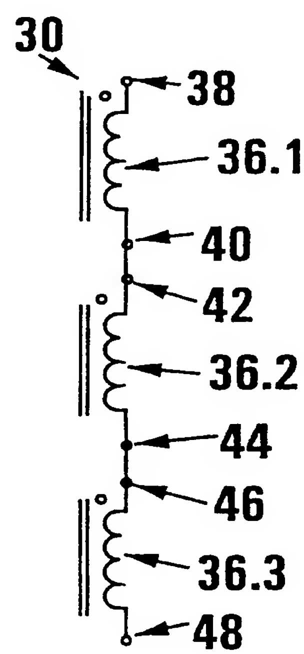
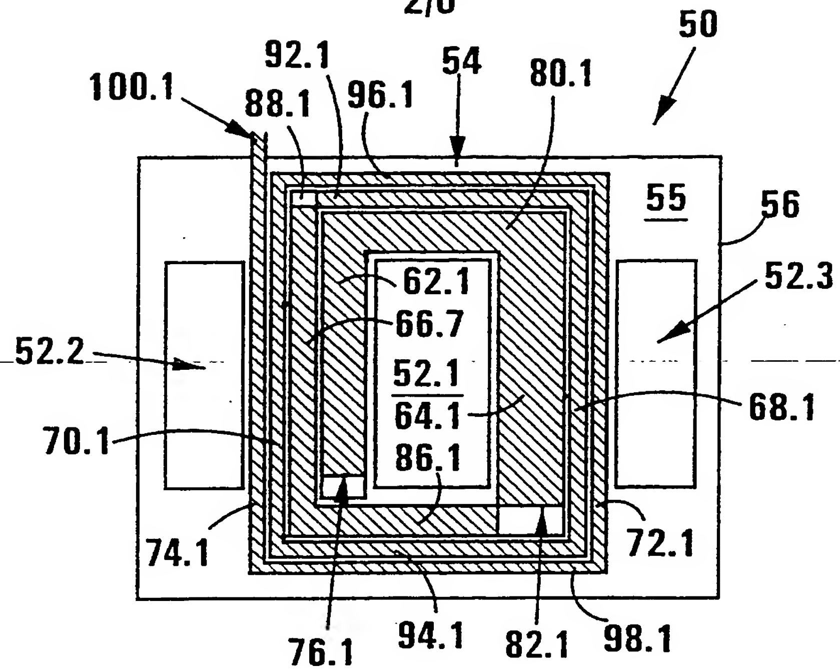


FIG 3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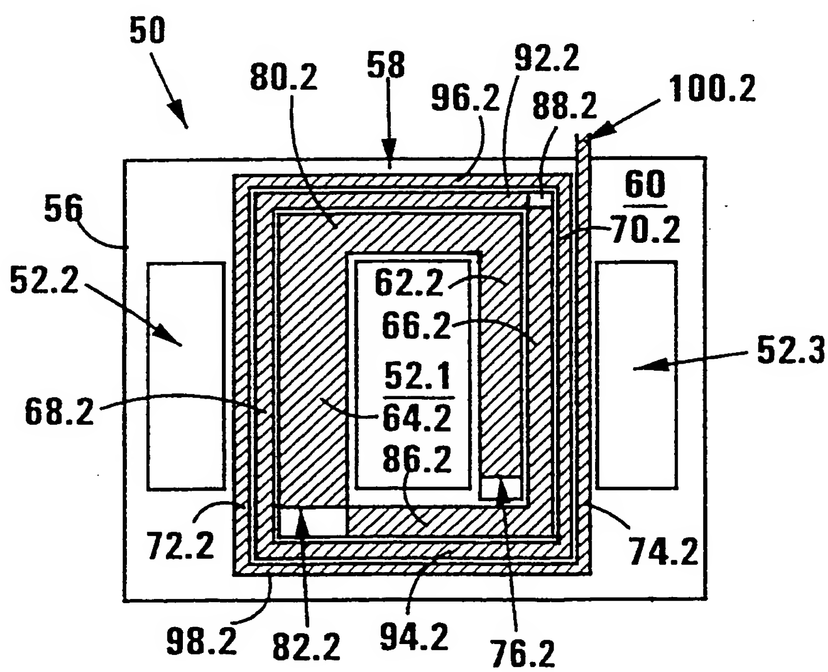
76.1
94.1
82.1
98.1

FIG 4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82.2
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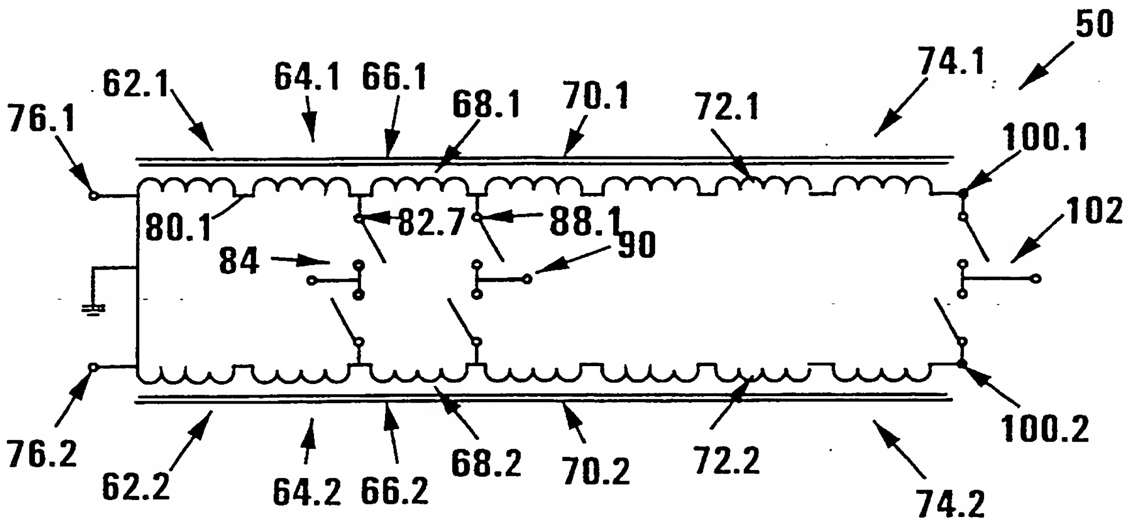
FIG 5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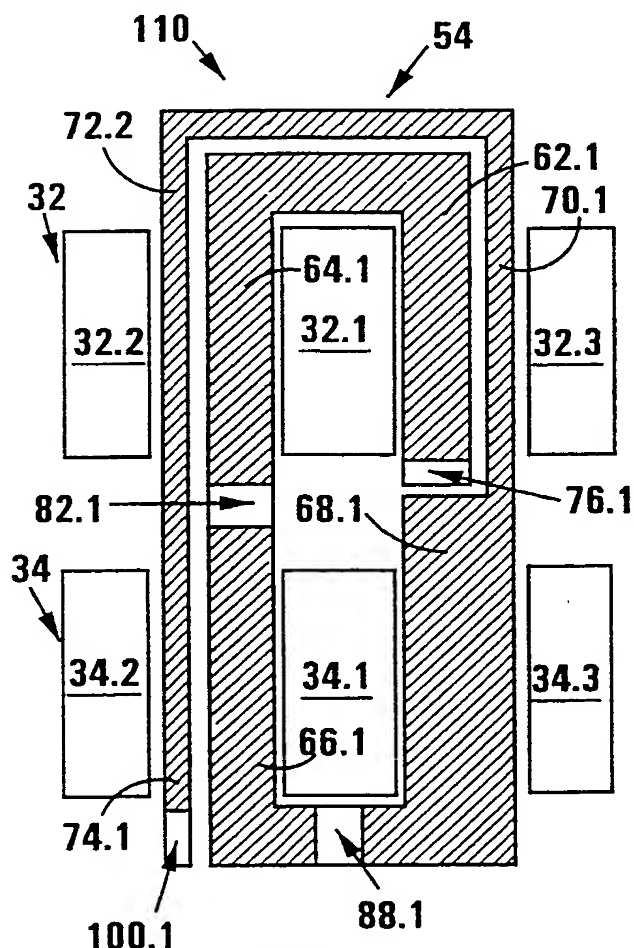
74.2
100.2

FIG 6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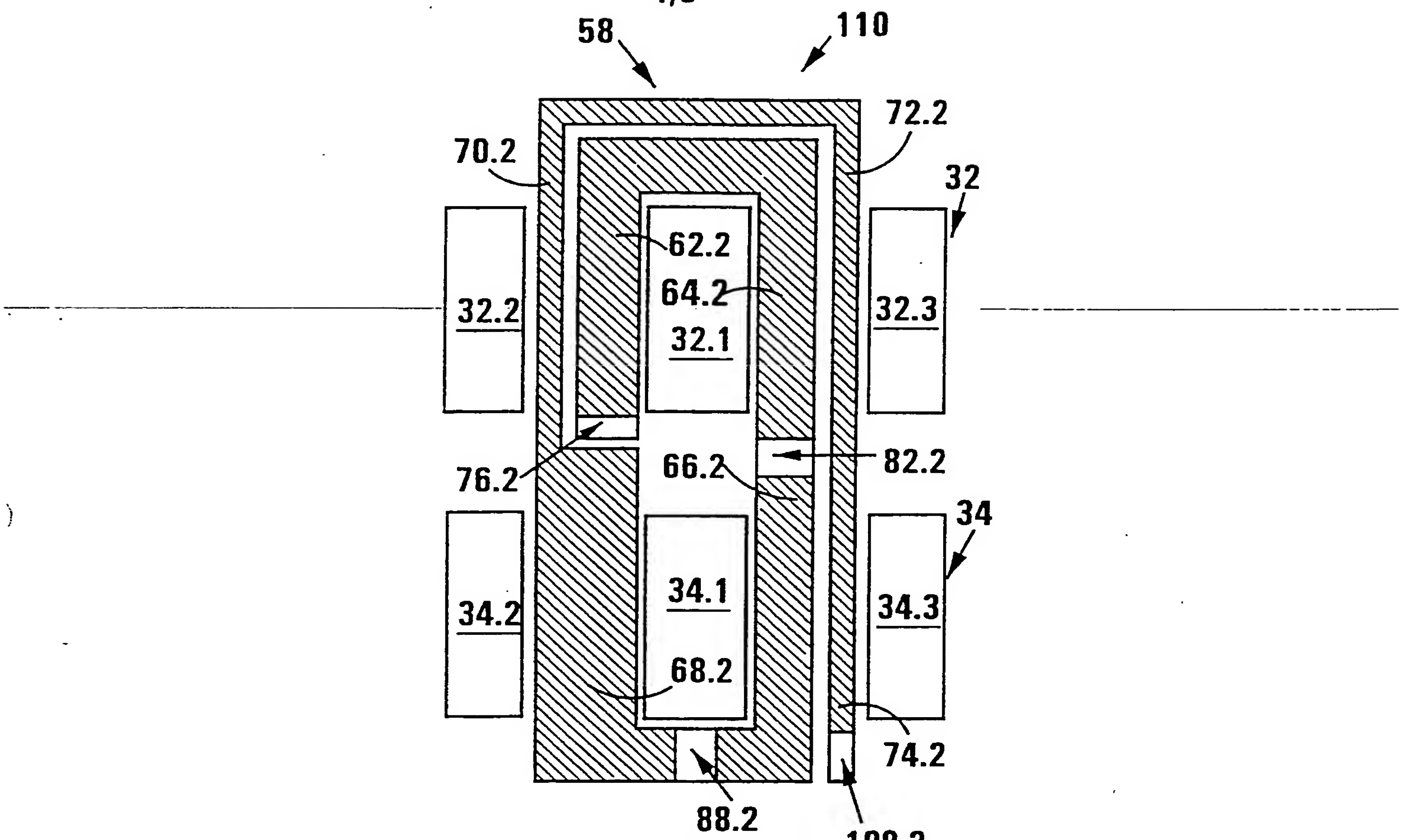
66.1
74.1
100.1
88.1

FIG 7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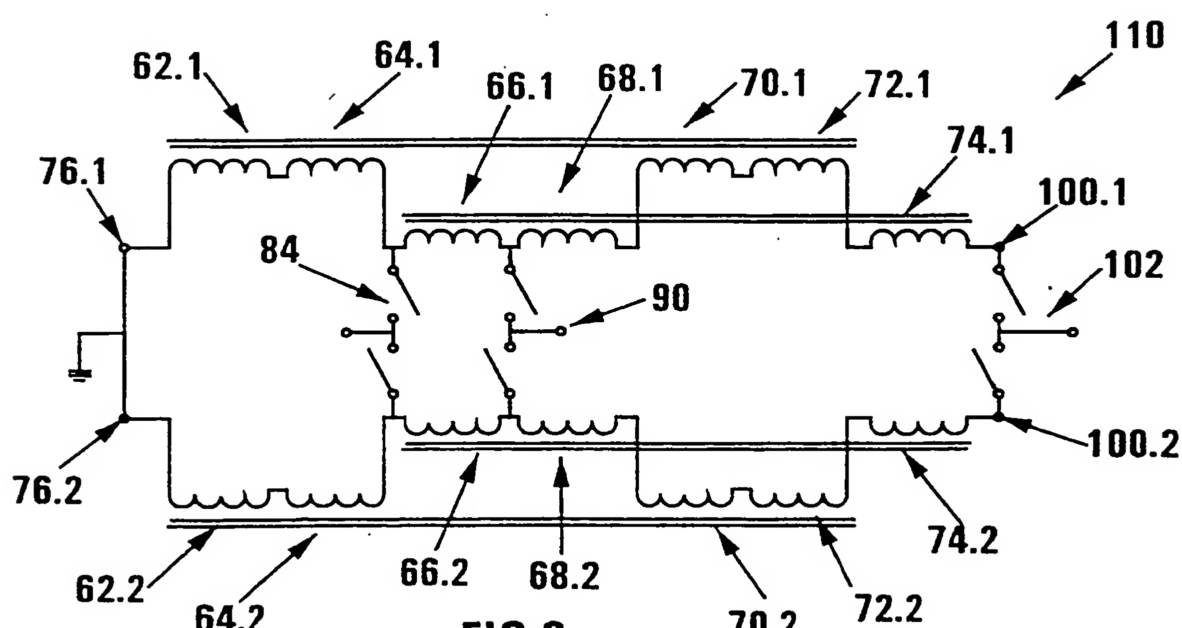
88.2
100.2

FIG 8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74.2
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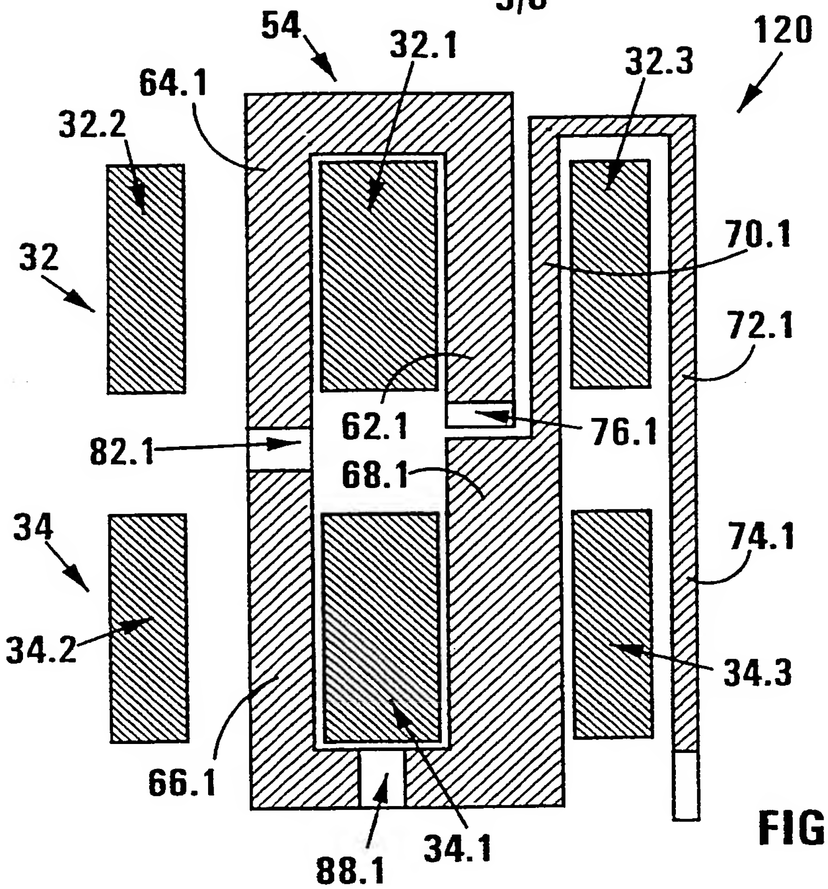
68.2
70.2
72.2

FIG 9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34.1
88.1

FIG 10

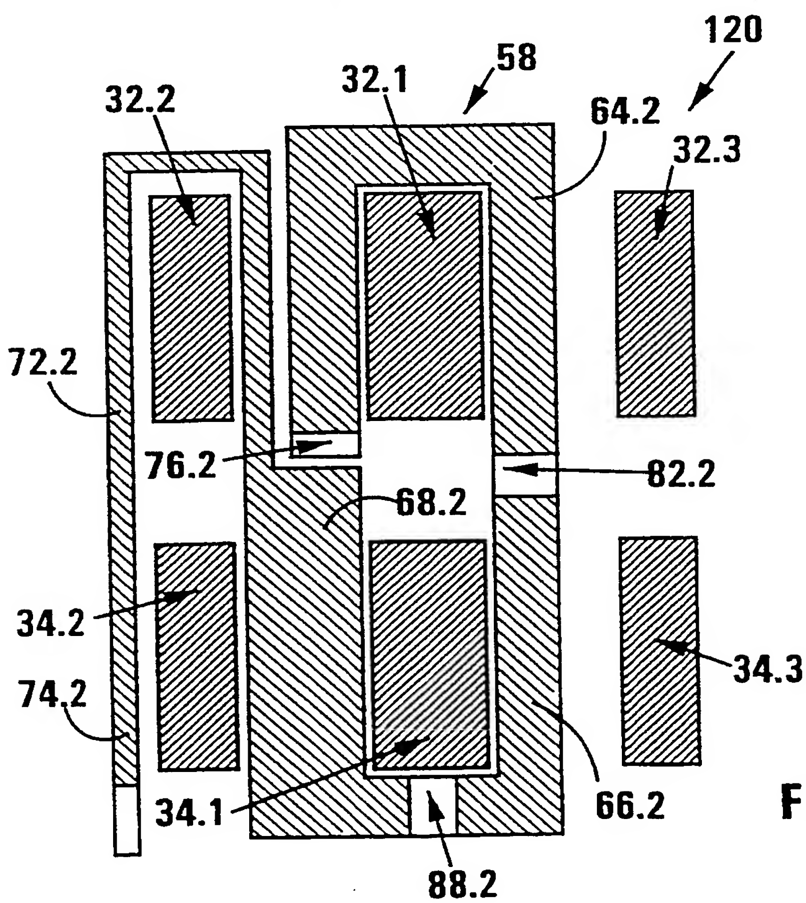
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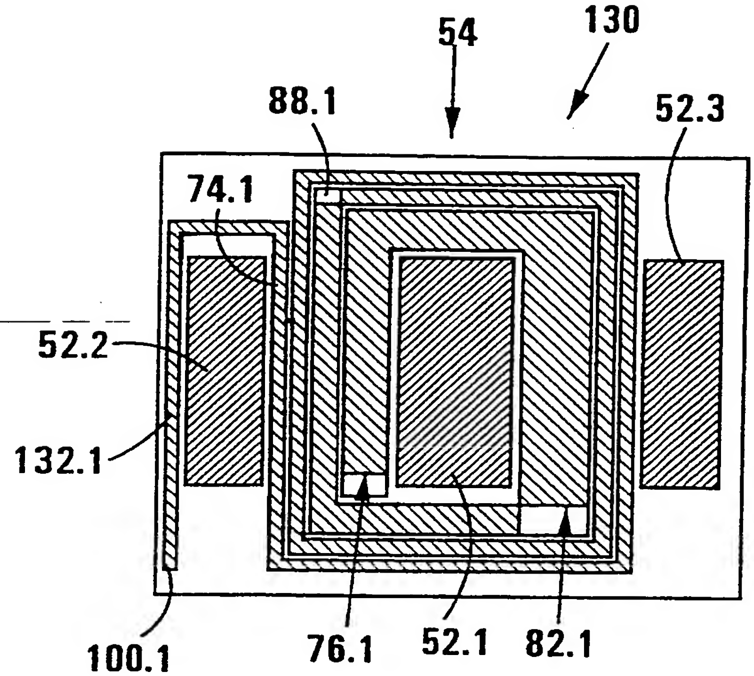
FIG 11



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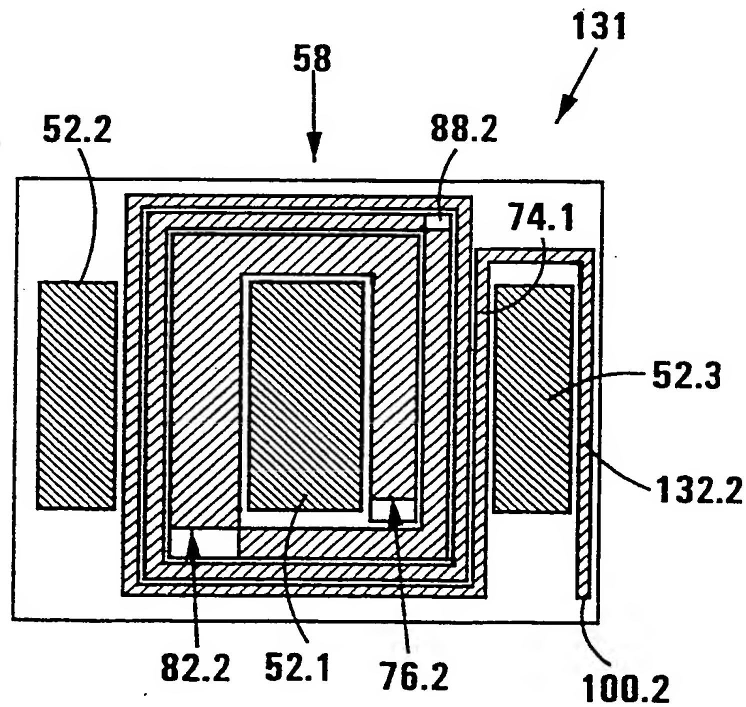
82.1

FIG 12



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88.2
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52.1
76.2
100.2

FIG 13

INTERNATIONAL SEARCH REPORT

International Application No
PC[illegible] 99/01410

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01F27/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 06112 A (INT POWER DEVICES INC) 12 February 1998 (1998-02-12) page 5, line 32 -page 7, line 16 ---	1,2,23
A	BEYER J: "SAT-VERTEILUNG MIT 2.400-MHZ-TECHNIK" FUNKSCHAU, no. 17, 2 August 1996 (1996-08-02), pages 64-67, XP000623289 ISSN: 0016-2841 ---	3,22
A	EP 0 371 157 A (SIEMENS AG) 6 June 1990 (1990-06-06) ---	
A	FR 2 476 898 A (MINI INFORMATIQ SYSTEM STE EUR) 28 August 1981 (1981-08-28) ---	

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 October 1999	29/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Vanhulle, R

1

International Application No
PCT/GB 99/01410

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT[illegible]99/01410

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